THE FOOD OF BROWN TROUT (*SALMO FARIO* L.).

BY

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(*With a plate*).

It is almost thirty years ago when brown trout was first introduced into the streams of the Kulu Valley in the Punjab, and since then it has been the main attraction for visitors to the Valley. It has provided good sport and good food. Yet, strange as it may appear, no attention has so far been paid to the problems the solution of which is necessary for the proper foundation of trout fisheries. For example, no precise information is available concerning the food and the feeding habits of brown trout during the various months of the year. It is evident that this subject is of paramount importance not only to the anglers for the immediate purpose of discovering the fly upon which the fish would come, but more so to those charged with the care and maintenance of trout waters. There is a general cry that trout fishing is degenerating. Is it so? If the answer is in affirmative, then we have to ask why?

Again, trout—an exotic species—has been introduced into Himalayan waters with consequent reaction on indigenous fauna and disturbance of balance of nature. What has been the influence of this on the composition of trout food and the cycle of events in the streams?

According to Southern (1935), for any intelligent conservation and improvement of trout fisheries it is necessary to know for each river and lake the following:

1. the age and rate of growth of the stock;
2. the kind and amount of food consumed;
3. the kind and amount of food available;
4. the effects on the food supply and on the number and rate of growth of the trout under various environmental conditions;
5. the extent of the natural spawning facilities and their relation to normal stock;
6. the capacity of the river to nourish fry of trout and to bring them to maturity.

A proper study of these problems will mean years of hard intelligent research and it is undoubtedly essential. Of the problems set out above, the present paper is concerned with the kind and amount of food consumed by brown trout in the Beas River in the Kulu Valley in the Punjab, as studied by the examination of its stomach contents.

The study of the food of trout has received much attention in Europe, America, Australia and New Zealand. The diet of trout has been found to consist of 'shrimps, water snails, insects, worms, etc., and small fish such as minnows and young of their own species.' (Regan 1911, Mottram 1928, 1931, Rushton 1931). Pentelow, (1932) in England, Metzellar (1929) in Michigan, Phillips (1929) in New Zealand and McKeown (1934 a, b) in Australia, investigated the food and feeding habits of trout by the examination of stomach contents and classified the contents as land insects, water insects, fish, crustacea, molluscs and such trash as gravel, wood and other debris.

Material and Methods.

The material, consisting of 102 stomachs of brown trout, was obtained mostly from anglers during the fishing season which lasts from the 1st March to the 30th October. No data on the food during winter months are available yet. The maximum weight of the fish examined was 3 lbs. 4 oz., and the minimum 3 oz. The lengths of these fish, up to the tip of the caudal fin, measured 190 mm. to 500 mm. Most of the fish were caught on[1] wet fly, i.e. artificial fly submerged just below the surface of water and imitating the nymphal stages of May flies and caddis flies. Some fish were caught on grasshoppers and worms. The bait in such cases was weighted and thus hooked mostly the bottom feeders.

The stomach contents consisted almost entirely of animal matter. The food in the front limb of the *U*-shaped stomach was, in most cases, almost undigested and was, comparatively speaking, easier to identify than that in the hind limb where its digestion had advanced. In the intestine, identification of the semi-digested food was impracticable.

In a preliminary study as this, no attempt has been made to make specific identification. Surveys of most of the aquatic insects and their immature stages in the Kulu Valley have not yet been carried out, and in the absence of such knowledge it was difficult to refer the collected material to species. The insect contents have, therefore, been classified into larger groups.

Results have been tabulated to show the distribution of various types of food taken by the fish for each month of the season. Under 'Unidentified' Coleoptera, Diptera and Hymenoptera, are included parts of insects and their larvae, and under 'Miscellaneous Insects' are shown such larvae and insects as were in a semi-digested condition and as such unidentifiable.

I am grateful to those anglers who supplied the stomachs of their catches, and I also owe my thanks to the Sub-Inspector of

[1] Fishing with a 'dry fly', i.e. by an artificial fly floating on the surface of water and imitating the winged insects, is only possible on slow running streams and has never been, and cannot be, practised on Himalayan streams.

Fisheries, Kulu, for assisting me in the collection work. I am grateful to my colleagues in the Entomological Section of the Punjab Agricultural College, Lyallpur, for the assistance which they gave in the identification of various insects.

Results of Stomach Examination.

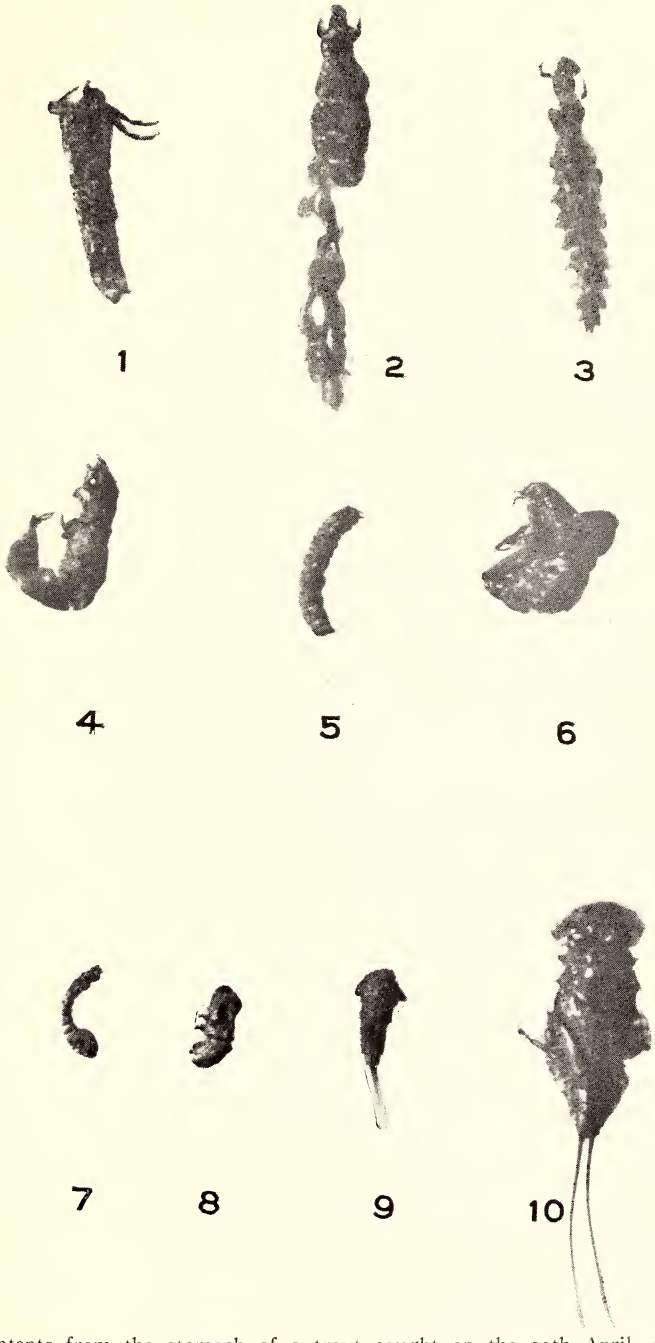
The trout is entirely carnivorous. The only indications of vegetable matter were small sticks found inside the stomachs in five cases. These had been swallowed along with caddis cases. In one specimen collected on the 20th May, 1937, 36 sticks were picked out. In two others, small grass seeds were found. No remains of water plants were found inside any stomach. The stomachs and intestines invariably contained sand and gravel-remnants of the caddis cases.

The contents of stomachs arranged in order of importance as food of trout, consisted of the following :—

(1) Insects : Caddis flies (Trichoptera), May flies (Ephemeroptera), Beetles (Coleoptera), True flies (Diptera), Ants and Wasps (Hymenoptera), Butterflies and Moths (Lepidoptera), Grasshoppers (Orthoptera), Dragon flies (Odonata), Earwigs (Dermaptera), Bugs (Hemiptera), Alder flies and Ant Lions (Neuroptera), and Stone flies (Plecoptera). (2) Pisces. (3) Arachnida. (4) Myriapoda. (5) Mollusca. (6) Crustacea. (7) Oligochaeta and (8) Amphibia.

Adult caddis flies were not found, and the larvae (Fig. 1-6), belonged to Sub-families Sericostomatidae, Hydropsychidae and Rhyacophilidae. No adult May flies were recorded and the larvae found (Figs. 9-10) belonged to *Baetis, Ecdyurus, Ephemerella* and *Iron*. Of the Coleoptera, adult forms of both the terrestrial and aquatic beetles were present, the former represented by Chrysomelidae, Carabidae and Scarabaeidae, had in all likelihood fallen from overhanging trees, or had been washed down by the floods and swallowed by the fish. Larvae of Curculionidae were fairly well represented in the stomachs of fish caught during September and October. Of the aquatic forms one adult Gyrinid was the only representative. The Diptera included the larvae of Simuliidae and Blepharoceridae (Figs. 7, 8), Cyclorrhapha and Syrphidae. Hymenoptera consisted of adult ants (Formicidae), Bees (Apidae), and wasps (Vespidae and Scolidae). The Lepidoptera consisted of caterpillars which could not be specifically identified. The Orthoptera included grasshoppers, which in two stomachs, collected in June, formed natural constituents of trout's diet, and in other cases were used as bait. The Odonata consisted of three Dragon fly larvae, and the Dermaptera, of three Earwig nymphs. Of the Neuroptera, two larvae (Sialioidea) were found in one stomach. Of the Plecoptera, only one larva was present in one specimen.

Out of the thirteen fish (Pisces) found in thirteen stomachs, one was definitely trout fingerling. It was found in the stomach of a fish, weighing 11 oz., collected on the 6th August, and measured 90 mm. in length. It filled the whole of the stomach, which had no other organism in it. In three cases, the stomachs



Contents from the stomach of a trout caught on the 11th April, 1937.
(*Photograph from actual specimens*).

Figs. 1-6. Caddis larvae (TRICHOPTERA).
Fig. 7. Simuliidae larva.
Fig. 8. Bleppharoceridae larva.
Figs. 9-10. May fly larvae (EPHEMEROPTERA).

contained barbel fry (*Oreinus sinuatus*), and in the remaining eight stomachs the fish fry was unidentifiable on account of its semi-digested condition.

The Arachnida consisted of two spiders, and the Myriapoda of one immature and one adult Scolopendra.

The Mollusca included one slug; and Crustacea were represented by one terrestrial Isopod; the Earthworms (Oligochaeta) had been used as bait. The Amphibia consisted of one tadpole found in a stomach collected in June.

Discussion.

Trout's diet: Practically any organism that is found in the water or on its surface is a possible food for the trout (Table I). The number of organisms found in a stomach varies according to the size of the organism swallowed. If the organisms are large in size, such as fish, frog or slug, their number is naturally small. But where small animals, such as caddis or May fly larvae are eaten, their number may be large. The largest number of caddis larvae taken from one specimen was 153 and there was nothing else inside the stomach. The stomach contents of a trout (Figs. 1-10), caught on the 11th April, 1937, consisted of 24 caddis larvae, 9 May fly larvae, one Blepharocerid larva, one Simuliium larva and two unidentifiable larvae. The various components of fish diet ennumerated above illustrate the variety and nature of trout's diet.

The influence of floods on the food of trout: In Tables II and III, stomach contents of fish, caught during the months of May and August, are given for comparing the food consumed by fish before and after the rains. In May, Trichoptera were found to the extent of about 60 per fish, while in August, the number had diminished to about 10. In May, one stomach out of 24, and in August 7 out of 14, contained fish fry. Out of 102 stomachs examined, 56 were collected after the rains, and out of these (Table IV), two in July, two in August, four in September and one in October, were found to be empty. That is to say, 16 per cent of the stomachs collected after the rains had practically no food in them. No empty stomach was found before the rains. Moreover the stomachs collected after the rains contained less food than those collected in the beginning of the season. The rains which commence in July, flood the river heavily and evidently cause great disturbance in the supply of available insect food.

Cannibalism: Out of 102 stomachs examined, only one case of cannibalism was recorded. It cannot, therefore, be said with any certainty that brown trout is cannibalistic in its habits. Mitchell (1914), working in Kashmir, also pointed out that in brown trout 'cannibalism is not natural and is only resorted to in special cases where other food is not available.' The question of cannibalism in trout requires thorough investigation, because if at any time food becomes scarce the life of little trout fry, with which the River Beas in the Kulu Valley is stocked annually, will be endangered.

Surface and submerged food: According to Pentelow (1932) a broad classification of the food can be made 'according to its origin, whether it is found on the surface of water or whether it is found in the water'. The former he calls 'surface' and the latter 'sub-surface' food. The greater part of the surface food, he remarks, 'consists of aquatic Diptera, Trichoptera, Ephemeroptera and Plecoptera. These insects after leaving the water have to return to it to lay their eggs and it is, therefore, natural they will make up the greater part of the surface food.' Sub-surface food is not defined by Pentelow (1932), but the term is meant to include all kinds of submerged food, whether free in the water or at the bottom of the stream.

Seasonal occurrence of surface and submerged food in the stomach of brown trout, (Table IV), indicates that the fish seem to feed on surface as well as submerged food during the whole of the season.

The abundance of submerged food and scarcity of adult flies in trout stomachs seem to show that the trout in the River Beas in the Kulu Valley is mostly a bottom feeder. For instance, while the larvae of caddis flies, commonly known to the anglers as *Grannom, Welshman's Button, Red Sedge, Cinnamon,* and of May flies called *March Brown, Olive Dun,* etc., form the principal constituents of trout food, adults of these insects are absent from stomach contents.[1]

Comparative study of trout's diet in various countries: A comparative statement of the average food per fish in the Kulu Valley, New Zealand (Phillips 1929) and New South Wales, Australia (McKeown 1934) is given in Table V. Comparison cannot be taken too far as the fish in the Kulu Valley, New Zealand and Australia live under entirely different environmental conditions, and the quantity of food varies not only according to the size of the fish but also according to the nature and density of the local fauna. Size of trout under study in the Kulu Valley varied from 3 oz. to 3 lbs. 3 oz. and of trout in Australia from 1 lb. to 4 lbs. Average weight of Kulu fish was, therefore, less than that of the Australian trout. Trout in the Kulu Valley, however, has practically the same variety of food as it has in other countries. A noticeable feature, however, is the negligible number of Crustacea and Mollusca in the stomachs of the Kulu trout.

It may be of interest to quote in this connection Mosely (1926), who commenting on Tillyard's Report (1921) on the effect of introduction of trout on the native insect fauna in New Zealand, adds that 'Nowadays trout are being introduced everywhere and perhaps we are deluded by the immediate success of our efforts. The history of New Zealand waters warns us that we must look beyond the immediate future and that stocking should be carried out on a very moderate scale, while sanctuaries for trout insect

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[1] On most parts of the River Beas it may, therefore, be said, that, as has also been pointed out by Howell (1914), 'the spoon and phantom and creeper will kill fish more readily than fly.'

food should be established in all areas where trout is being introduced. Crustaceans and Molluscs should be imported if not already present, to offer an alternative diet to the fish. Otherwise, the trout may thrive lustily in the virgin waters, increase abundantly, and by reason of their well doing, doom themselves to inevitable destruction.'

The effect of introduction of trout on the native insect fauna of the Kulu Valley is not known. The present investigations, however, indicate that though there is no immediate danger to the depletion of aquatic fauna, yet the food of trout in the Kulu Valley requires immediate attention. The present investigations, it is believed, will give sufficient impetus to further research on the subject and steps will be taken to improve the food of trout by establishing sanctuaries for insects, as advised by Mosely (1926), in side streams where trout should not be allowed to penetrate and also efforts will be made to introduce some suitable Crustacea and Mollusca to offer an alternative diet to the fish.

Summary.

1. The food of the brown trout (*Salmo fario* L.) living in the Beas River in the Kulu Valley in the Punjab has been investigated by the examination of stomach contents of 102 fish.

2. The food consists of aquatic and terrestrial insects and their larvae such as Caddis flies (*Trichoptera*), May flies (*Ephemeroptera*), Beetles (*Coleoptera*), True flies (*Diptera*), Ants, Bees and Wasps (*Hymenoptera*), Butterflies and Moths (*Lepidoptera*), Grasshoppers (*Orthoptera*), Bugs (*Hemiptera*), Alder flies and Ant Lions (*Neuroptera*) and Stone flies (*Plecoptera*). Besides insects, the trout feeds also on young fish (*Pisces*), Spiders (*Arachnida*), Scolopendra (*Myriapoda*), Snails and Slugs (*Mollusca*), Crustacea, Worms (*Oligochaeta*), Frogs and Tadpoles (*Amphibia*). Crustacea and Mollusca are present in negligible quantities in the stomachs, and the worms present were in all cases used as bait.

3. The stomachs collected after the rains contain smaller quantities of food than those collected early in the season. No empty stomach was found before the rains, but 16 per cent of the stomachs collected after the rains, were empty. The rains cause heavy floods and disturb the supply of available food in the river.

4. Disturbance in the supply of available food after the floods probably drives the trout to feed on fish fry.

5. The abundance of submerged food and scarcity of winged flies in the stomachs seem to indicate that the trout in the Beas River is mostly a bottom feeder.

6. The trout in its Indian habitats is consuming practically the same variety of food as in England, New Zealand, Australia and America.

TABLE I.

Monthly comparison of stomach contents of Brown Trout (*Salmo fario* L.) from the River Beas in the Kulu Valley.

	April 1937	May 1937	June 1937	July 1937	Aug. 1937	Sept. 1937	Oct. 1937	Total
Number of stomachs examined ...	13	24	9	11	14	27	4	102
TRICHOPTERA ...	397	1439	67	135	138	103	10	2289
EPHEMEROPTERA ...	43	38	2	2	7	30	4	126
COLEOPTERA								
Gyrinidæ ...	...	...	...	...	1	...	...	1
Curculionidæ ...	...	...	...	...	...	39	10	49
Chrysomelidæ ...	...	2	...	...	...	2	...	4
Carabidæ ...	1	2	1	...	...	2	...	6
Scarabæidæ ...	...	...	3	...	...	4	...	7
Unidentified ...	...	8	26	2	2	7	1	46
DIPTERA								
Blepharoceridæ ...	2	2	1	...	...	4	5	14
Simuliidæ ...	1	1	...	...	...	2	..	4
Cyclorrhapha ...	...	38	...	...	...	...	...	38
Syrphidæ ...	...	...	...	...	1	...	1	2
Unidentified ...	1	4	...	3	1	...	2	11
HYMENOPTERA								
Formicidæ ...	...	17	3	8	2	34	...	66
Apidæ ...	...	...	1	...	...	2	...	3
Vespidæ ...	...	...	...	...	...	1	..	1
Scoliidæ ...	...	1	...	...	...	...	...	1
Unidentified ...	...	1	...	1	...	1	...	3
LEPIDOPTERA ...	...	4	7	..	...	1	1	13
ORTHOPTERA								
Acridiidæ ...	...	1	10	1	1	4	...	17
Mantidæ ...	...	...	...	...	...	1	...	1
ODONATA ...	1	1	...	1	...	...	...	3
DERMAPTERA ...	...	3	...	...	...	...	...	3
HEMIPTERA								
Capsidæ ...	...	...	...	...	...	...	1	1
Jassidæ ...	...	1	...	...	...	...	...	1
NEUROPTERA								
Sialioidea ...	...	..	2	...	...	...	...	2
PLECOPTERA ...	...	1	...	...	...	...	...	1
MISCELLANEOUS INSECTS ...	5	19	8	1	4	2	...	39
PISCES ...	3	1	2	...	7	...	...	13
ARACHNIDA ...	1	...	...	...	1	...	...	2
MYRIAPODA ...	...	...	...	1	...	...	1	2
MOLLUSCA ...	...	...	...	1	...	...	...	1
CRUSTACEA								
Isopoda ...	...	...	...	1	...	...	...	1
OLIGOCHAETA ...	...	...	...	2	...	...	...	2
AMPHIBIA ...	...	...	1	...	...	...	...	1
MISCELLANEOUS								
Sand-gravel ...	o	o	...	...	o	...	...	
Twigs-seeds ...	o	o	...	...	o	o	...	

o Indicates presence.

TABLE II.

Summary of stomach contents of each Brown Trout (*Salmo fario* L.) caught from the River Beas in the Kulu Valley during the Month of May 1937.

																									Total
Serial number of stomachs.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Length in mm.	...	287	275	337	287	275	256	256	300	275	269	275	300	275	275	250	250	350	287	350	300	300	275	262	300	
Weight in oz.	...	10	9	16	10	8	7	6	10	8	7	9	11	10	10	7	7	14	10	17	11	10	9	8	10	
Sex	...	F	F	M	M	M	M	M	F	M	M	F	M	M	F	M	M	F	F	F	F	M	F	F	M	
TRICHOPTERA	...	125	3	24	42	83	82	119	42	107	12	12	2	127	49	26	23	17	4	78	153	101	106	49	53	1439
EPHEMEROPTERA	...	1	...	...	...	8	1	...	1	...	..	...	1	2	1	2	10	3	2	2	...	...	2	1	1	38
COLEOPTERA																										
Chrysomelidæ	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Carabidæ	...	...	...	...	..	...	...	...	...	...	...	2	...	...	...	..	...	...	...	...	...	...	...	...	...	2
Unidentified	...	...	...	...	1	...	...	...	1	1	...	...	...	...	...	...	...	1	4	...	...	...	...	...	...	8
DIPTERA																										
Blepharoceridæ	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Simuliidæ	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	1
Cyclorrhapha	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	36	...	38
Unidentified	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	4
HYMENOPTERA																										
Formicidæ	...	...	...	...	...	...	...	1	...	1	...	1	...	3	...	...	1	3	4	...	...	...	...	2	1	17
Scoliidæ	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Unidentified	...	...	...	...	..	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1
LEPIDOPTERA	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1	...	2	...	...	...	...	...	...	...	...	4
ORTHOPTERA																										
Acridiidæ	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	1
ODONATA	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1
DERMAPTERA	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	3
HEMIPTERA																										
Jassidæ	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	1	...	...	...	...	...	...	...	...	...	1
PLECOPTERA	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1
MISC. INSECTS		...	...	...	...	...	...	...	...	...	...	...	1	4	...	...	5	8	...	...	...	...	1	...	...	19
PISCES	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1
MISCELLANEOUS																										
Sand-gravel	...	o	o	o	o	...	...	...	...	...	...	...	...	...	...	...	...	...	...	o	o	o	o	o	o	
Twigs-seeds	...	...	...	...	...	...	...	...	...	...	...	...	...	o	...	...	...	...	...	...	...	o	o	o	o	
Digested remains	...	...	...	...	...	...	...	...	...	...	o	o	...	o	...	...	o	o	o	...	o	...	o	o	o	

F = Female. M = Male. o indicates presence.

TABLE III.

Summary of stomach contents of each Brown Trout (*Salmo fario* L.), caught from the River Beas in the Kulu Valley during the Month of August, 1937.

															Total
Serial number of stomachs ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14
Length in mm. ...	325	312	287	300	225	325	250	250	300	312	300	250	325	362	
Weight in oz. ...	13	12½	11	11	5	12	8	8	10	14	13	6	16	20	
Sex ...	M	F	M	F	M	F	M	M	F	M	M	F	M	M	
TRICHOPTERA ...	..	...	...	...	...	28	87	5	18	...	...	...	...	...	138
EPHEMEROPTERA.	...	...	...	...	...	3	1	1	...	...	2	...	...	...	7
COLEOPTERA															
Gyrinidæ ...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1
Unidentified ...	...	2	...	...	...	...	...	...	...	..	...	...	...	...	2
DIPTERA															
Cyclorrhapha ...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
Syrphidæ ...	..	...	...	...	...	...	...	...	...	...	1	...	...	...	1
HYMENOPTERA															
Formicidæ ...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	2
ORTHOPTERA															
Acridiidæ ...	...	...	...	...	...	1	...	..	...	...	...	...	...	...	1
MISC. INSECTS ...	1	...	...	...	...	2	...	1	...	...	...	...	...	...	4
PISCES ...	1	1	1	1	...	1	...	...	...	...	...	...	1	1	7
ARACHNIDA ...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1
MISCELLANEOUS.															
Sand-gravel ...	...	...	...	...	...	...	o	...	...	...	...	...	...	...	
Twigs-seeds ...	...	...	...	...	...	o	...	...	...	...	...	...	...	...	
Digested remains ...	..	...	...	...	...	...	o	o	...	...	...	...	...	...	

F = Female. M = Male. o indicates presence.

TABLE IV.

Seasonal occurrence of surface and submerged food in the stomachs of Brown Trout (*Salmo fario* L.) in the River Beas in the Kulu Valley.

	April	May	June	July	August	September	October	Total
Number of stomachs examined ...	13	24	9	11	14	27	4	102
Empty stomachs ...	...	...	...	2	2	4	1	9
Stomachs with surface food ...	...	...	...	...	...	9	...	9
Stomachs with mixed surface and submerged food ...	2	2	5	4	2	10	2	27
Stomachs with submerged food ...	11	22	4	5	10	4	1	57